2009 International Workshop on Environment and Alternative Energy

AFRL
THE AIR FORCE RESEARCH LABORATORY
LEAD | DISCOVER | DEVELOP | DELIVER

NASA

AIR FORCE SPACE COMMAND

Lt Casey Matthews
Aerospace Coatings Project Manager
Coating Technology Integration Office
US Air Force Research Laboratory

Agenda

Agenda

Key Players:

AFCTIO
AFCPCO
AFSPC
NASA

Tech Overview:
Metallization

Metal Wire Arc Spray

Cold Spray Technology

Metallization Project

Time	Topic	Speaker	Organization
0900-910	Opening Remarks	Lt William Matthews	AFRL/RXSSO
0910-0930	Corrosion Control in USAF	Lt William Matthews	AFRL/RXSSO
0930-0950	Tech Overview of Metalization	Lt William Matthews	AFRL/RXSSO
0950-1010	AFRL's Roll in Corrosion	Lt William Matthews	AFRL/RXSSO
1010-1025	BREAK		
1025-1045	ESA	TBD	ESA
1045-1105	Hex –chrome & Lead reduction efforts	Kurt Kessel	Senior Engineer
1105-1125	Nitric Acid Passivation	Matt Rothgeb	Senior Engineer
1125-1300	Breakout/Wrap-up		

AFCTIO

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Materials Management & Substitution

Lt William "Casey" Matthews
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937-656-9567
William.Matthews@wpaf.af.mil

Corrosion Control in the USAF

- **Key Players**
  - AFCTIO
  - AFCPCO
  - HQAFSPC
  - NASA

Key Players:
USAF Coatings Technology Integration Office

- ***Engineer (Integrate) new coatings systems, processes and equipment into new aircraft coating system capability***
- **Transition advanced, environmentally qualified products into everyday use**
- **Quick reaction troubleshooting for field problems on new coating systems**

Key Players:
USAF Coatings Technology Integration Office

- **TRL Explained**
- **Hot Dip Galvanization for AGE**
- **Deployable UV Cure Kit**
- **UV Cure Stencils**
- **Chrome Free Coating Systems**
  - **Sicopoxy/ Alodine 5200**
  - **Magnesium Rich Primers**

AFCTIO

Technology Readiness Assessment

Agenda
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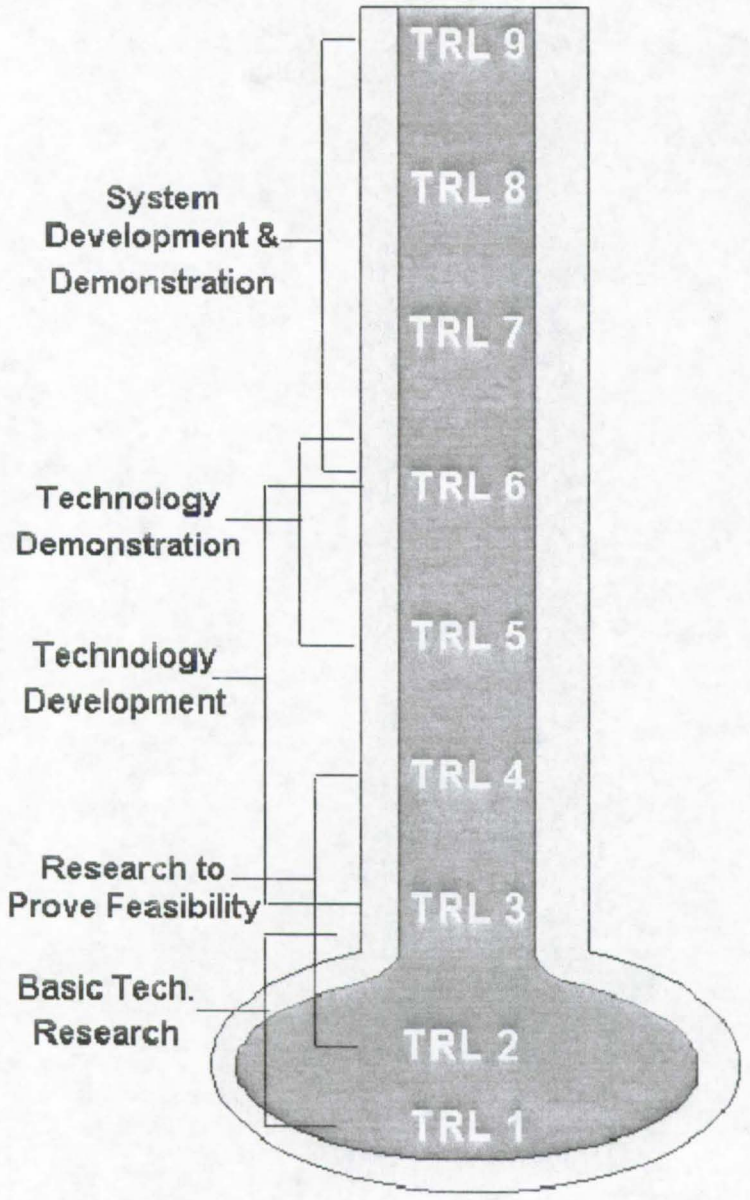

Technology Readiness Level (TRL)

(Definitions taken from DoD 5002-R, 5 Apr 2002)

Technology Readiness Assessment

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TRL 9	• **Best material formulation, application processes, and equipment proven through successful mission operations**
TRL 8	• Best material formulation, application processes, and equipment qualified through test and demonstration
TRL 7	• Best material formulation, application processes, and equipment demonstrated in an operational environment
TRL 6	• Best material formulation, application processes, and equipment demonstrated in a relevant environment
TRL 5	• Top material formulations validated in a relevant environment
TRL 4	• Candidate material formulations tested against full spectrum of tests in laboratory. Material specification is frozen
TRL 3	• Screening test weed out poor material formulations. Detailed material specification is developed
TRL 2	• **Material formulations vary wildly. Key requirements are documented**
TRL 1	• **Basic principles of materials observed and reported. Requirements are non-specific and incomplete**

Hot Dip Galvanization for GSE

TRL 7

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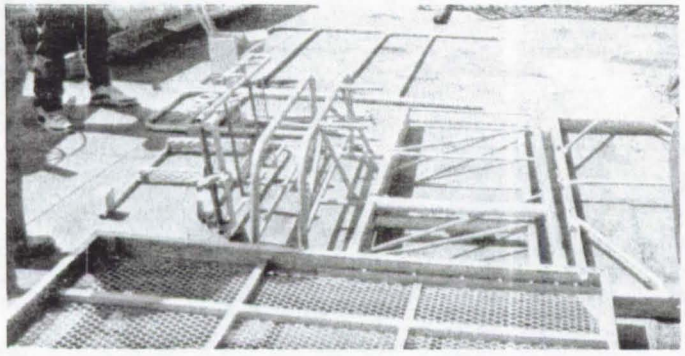
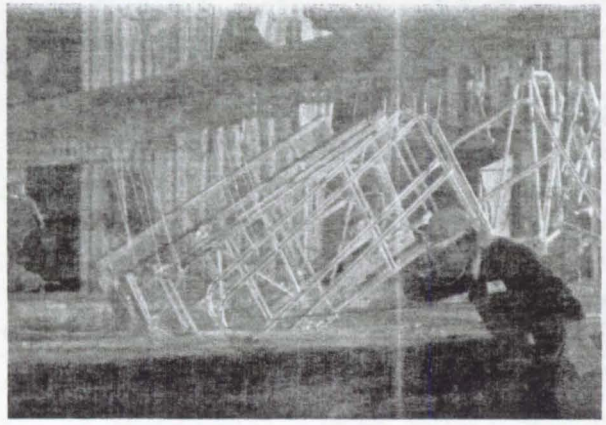
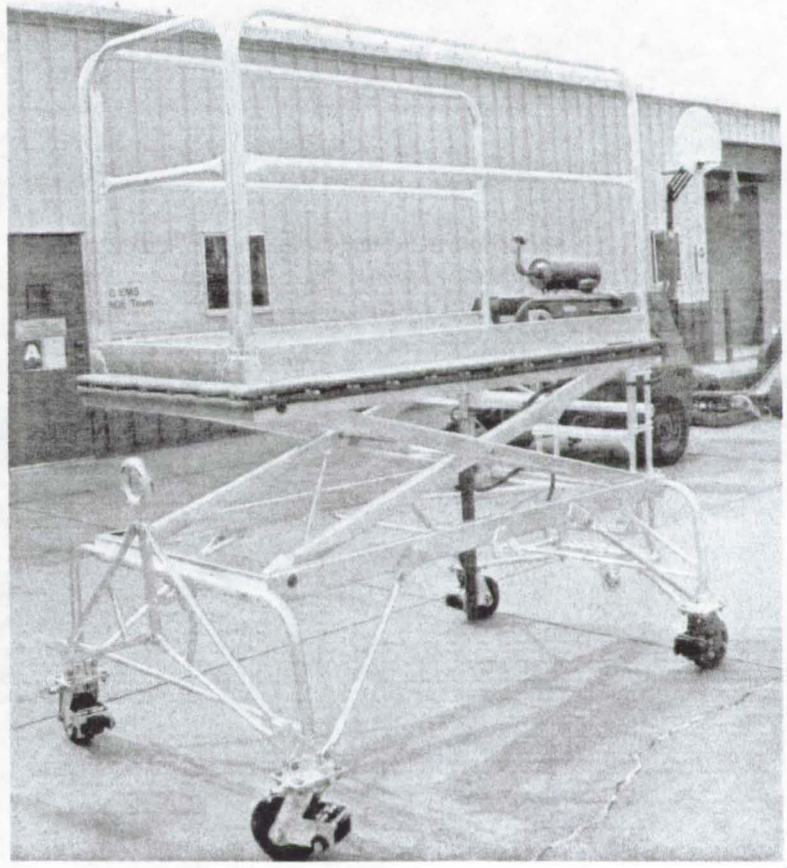
CTIO initiated a project in Sep 07 at the request of PACAF to investigate HDG for support equipment in highly corrosive environments.







Deployable UV Cure Kit (DUCK)

TRL 4

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Tech Overview:
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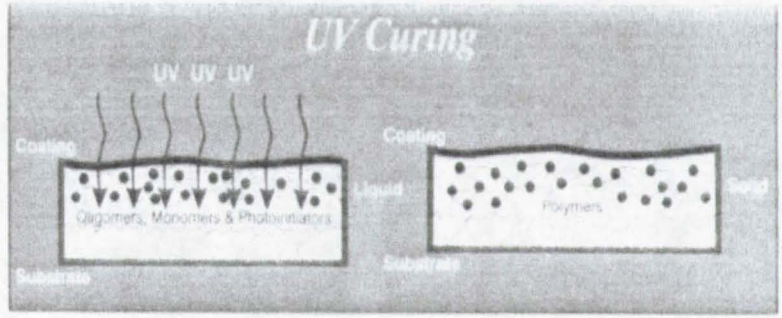
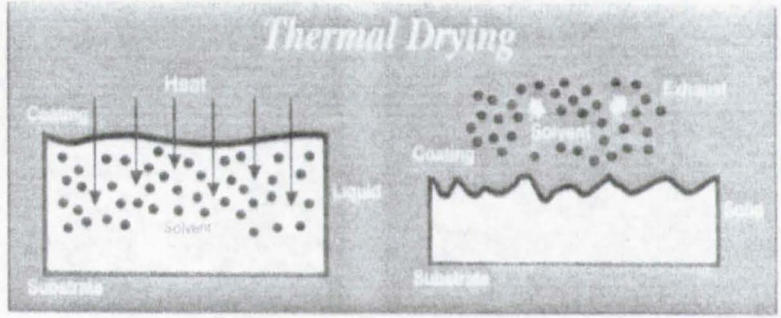
Cold Spray Technology Metallization Project

- **UV cure is a method of rapid-curing a coating with a UV Curable coating**
- **These are coatings/paints that cure in seconds/minutes under UV light rather than 3+ days via chemical reaction (as with today's polyurethane topcoats)**
- **Perform the necessary tests to ensure the coating systems are capable to be applied to the airframe with the same effectiveness as current Mil –Spec coatings**
- **UV coatings typically have very low to 0 VOC's**
- **UV coatings are typically temperature independent, will cure in cold temperatures**

Compare for Yourself



Vs.



Since solvent-based thermal drying evaporates solvents, the initial laydown is typically reduced by more than 50%. UV curing uses no solvents, so chemicals in the coating cure instantly with no loss of film thickness.

Deployable UV Cure Kit (DUCK)

TRL 4

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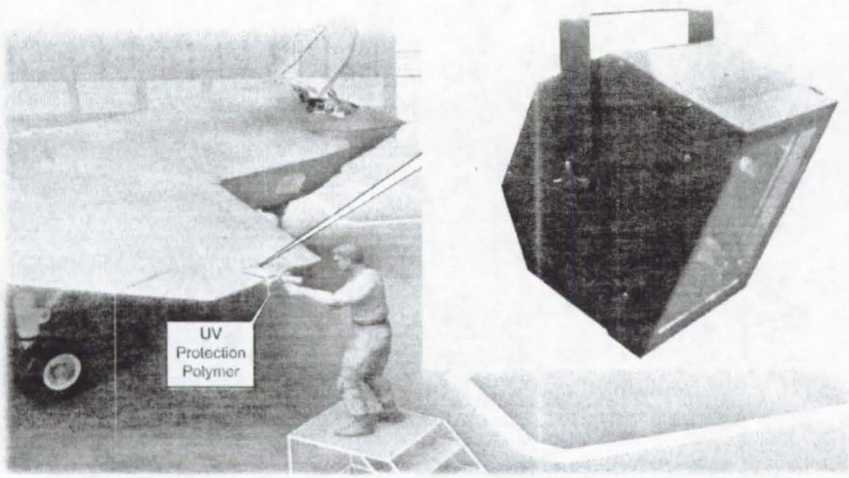
Cold Spray Technology
Metallization Project

- **Purpose:**
  - Deliver UV technologies out to the Field
  - Develop a kit capable of curing a small repair <9ft^2 in less than 4 hrs
  - Will allow maintainers to do flight line touchups in environmentally restrictive areas



- **Kit will include**
  - **UV lamp (Hg Arc)**
  - **UV Cure coatings**
    - **Topcoats**
    - **Primers**
    - **Pretreatments**
- **Training Video**
- **Restocking Information**
- **PPE/MSDS**
- **Small telescoping stand**
- **Carrying Case, to be able to be deployed by 1 technician**

UV-Curable Stencils/Markings

TRL 5

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UV-Curable Coatings – cure only when exposed to correct dose/intensity of UV light at specific wavelengths

- **Single Component, no mixing, no waste**

Advanatages:

- **Required cure time is seconds or minutes vs. 3 – 7 days required for conventional polyurethane systems**
- **Environmentally friendly – usually low/zero VOC**
- **Enables extremely rapid touch-ups and repainting**

AFRL Approach: Capitalize on low risk, potentially high reward applications to demonstrate the technology…

UV-Curable Stencils/Markings

TRL 5

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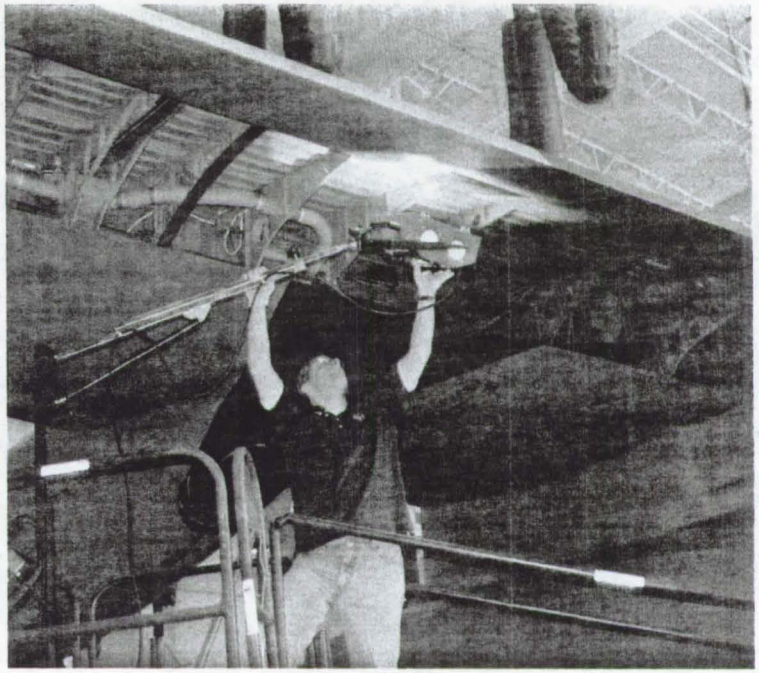
1st App: Iowa ANG, Dec 07, F-16 tail



2nd App: 911 AW, Apr 08, C-130

Nov 08 Eval – 7 months and 340+ flying hours

- **No adhesion loss; color degradation ~1/2 that of the conventional markings on aircraft**

Alodine5200/Sicopoxy/Deft ELT

Non-Chrome Coating System

TRL 7

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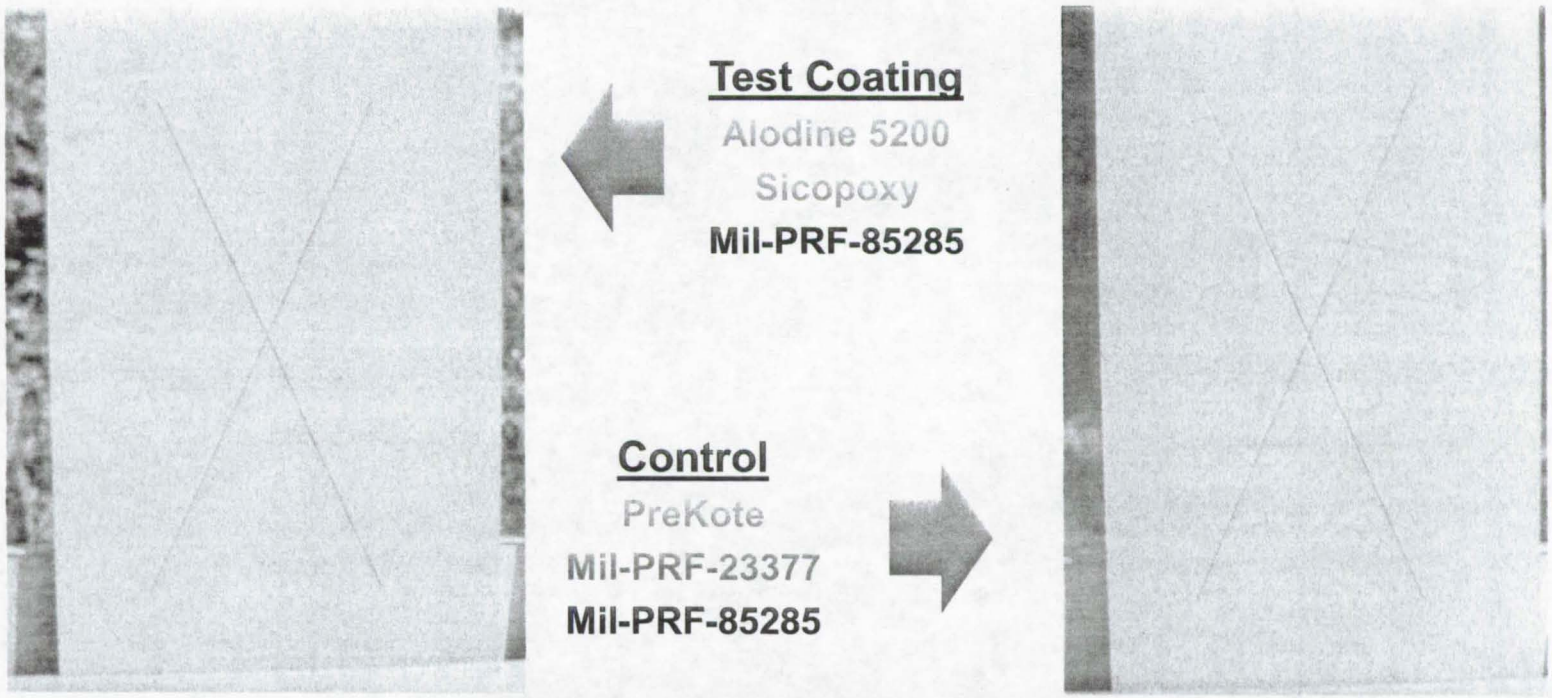
- **Lab Testing: Alodine 5200/Sicopoxy/Deft ELT (APC) Nonchrome system performed the best of all Nonchrome Systems evaluated**
- **Daytona Beach outdoor exposure: results at 9 months**



- **CTIO, AFCPCO, & RXSC worked with AETC to conduct a field test of Alodine 5700/Sicopoxy/Deft ELT (APC) @ Randolph AFB**

NOTE: Alodine 5200: Concentrate --- Alodine 5700: Premixed RTU

Alodine5200/Sicopoxy/Deft ELT

Non-Chrome Coating System

TRL 7

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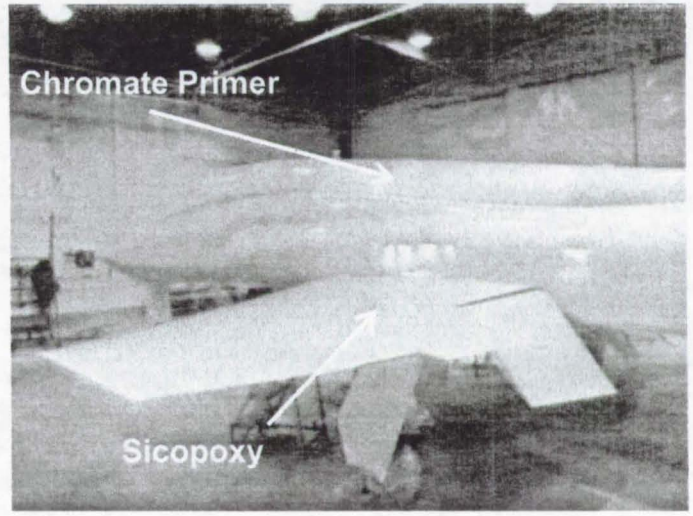
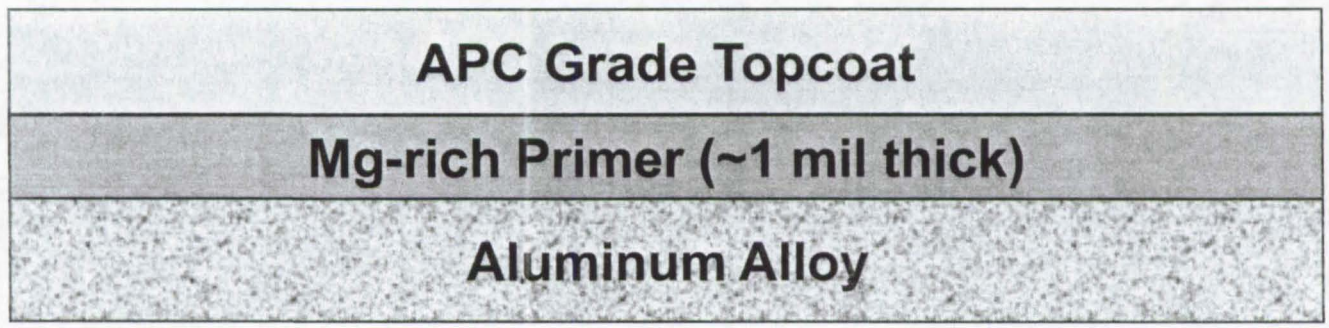
Field Test

- **T-38**
  - **Test Area:** ~45% of left side
  - **Coating System:**
    - Alodine 5700
    - SICOPOXY
    - MIL-PRF-85285
  - **Application:** Randolph Sept 08
  - **Deployed:** Randolph
- **Evaluate:** 6 months and 1 year
- **Rate of Corrosion:** monitored by sensors at Randolph AFB



Mg-Rich Primer
What is it?

TRL 4+



No Chromate Conversion Coating

- Developmental non-Cr primer as part of a fully non-Cr coating system
- Concept developed by NDSU
- Licensed & product development by a major aerospace coating company
- Provides "cathodic" corrosion protection of the substrate
  - analogous to a Zn-rich primer for steel
  - does not use inhibitors
- NEW TECHNOLOGY = NEW RULES; still some unknowns, may require special considerations
- Designed as "Drop In" for MIL-PRF-23377
- Best results with PreKote.

Mg-Rich Primer
How does it work?

TRL 4+

Agenda
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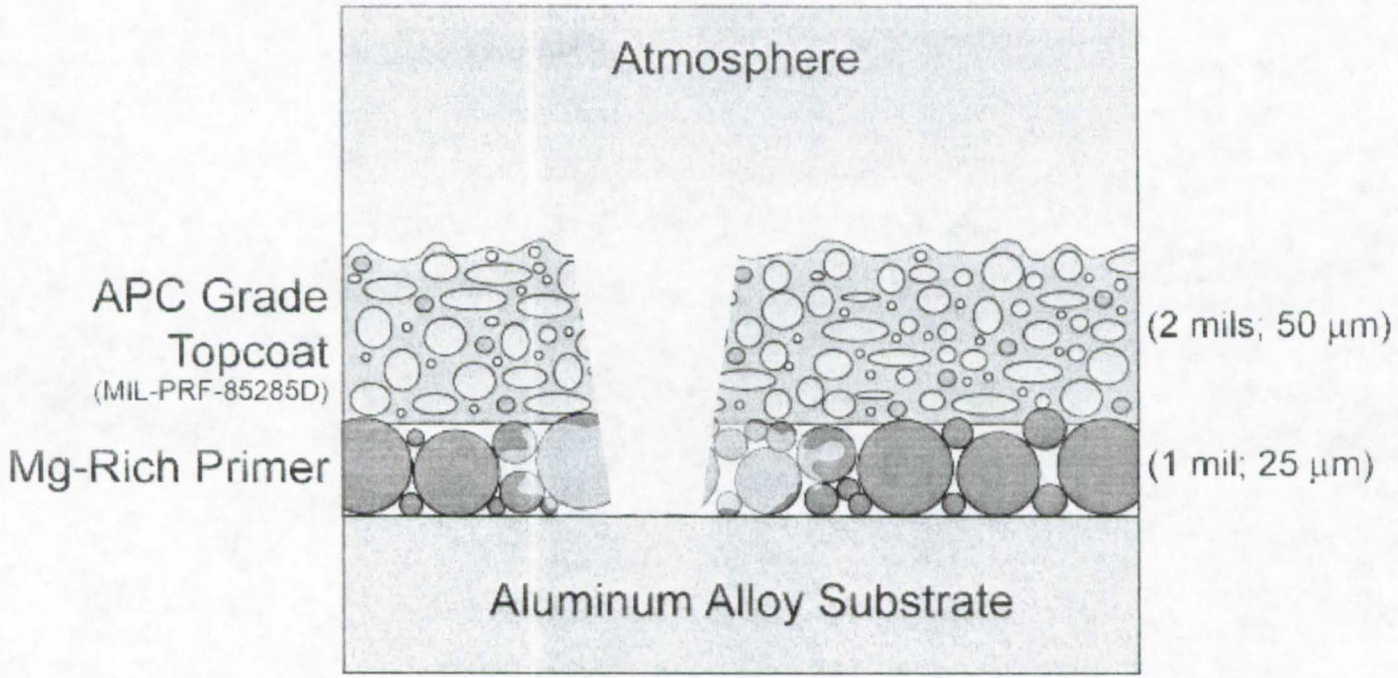
- **<u>Corrosion Prevention</u>: provided by barrier properties of the primer and topcoat (conventional); both Mg pigment and substrate protected**



- **<u>Corrosion Control</u>: Mg particles are more active than the aluminum; the pigment corrodes and the substrate doesn't**

Mg Rich Primer
Status

TRL 4+

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- **Inconsistent Results:** Navy, CTIO, and Outdoor Exposure
- **Round Robin:**
  - 5 Organizations: B-117 **- Terminated at 500 hours**
  - 2 Organizations: Daytona Beach and KSC
- **Navy pursuing patent for possible fix**
- **Akzo Nobel working on issue:**
  - Briefed CTIO 23 January 2009 – Found Solution
- **Samples shipped to CTIO mid March –** Testing underway
- **GOAL: F-16 Field Test** and **MIL-PRF-32239 Qualification**
  - If screening tests successful

Co-Inhibitor Study: 1500 Hours Neutral Salt Spray
Topcoat: Aerodur 5000, Substrate: 2024-T3

TRL 4+

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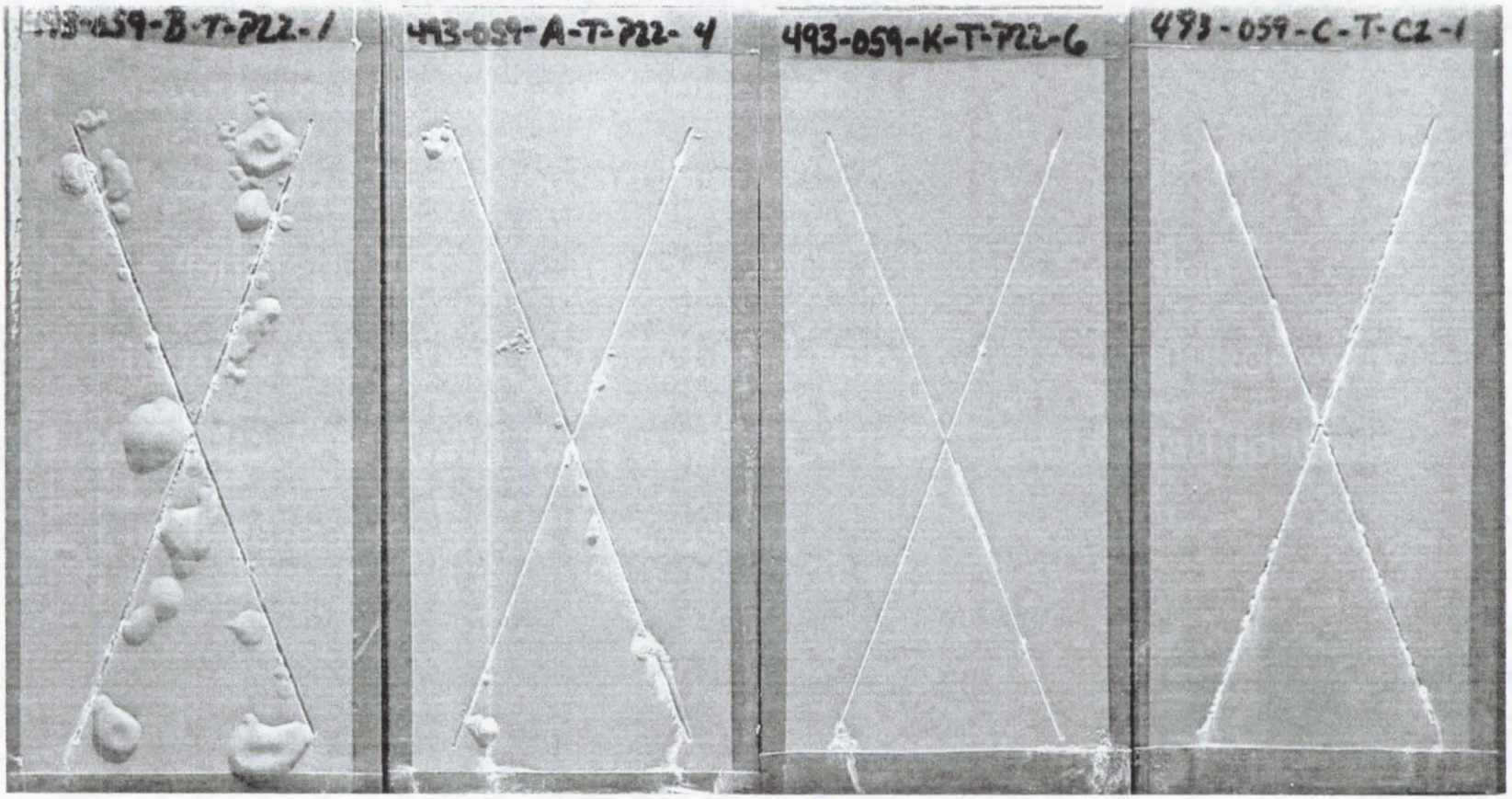
Negative Control over PreKote	Standard MgRP over PreKote	Inhibitor 2 w/ MgRP over PreKote	10P8-11 over Alodine 12000



Key Players:
USAF Corrosion Prevention and Control Office

Ensure the Air Force has an effective program to prevent, detect, and control corrosion and minimize the impact of corrosion on Air Force combat capability.

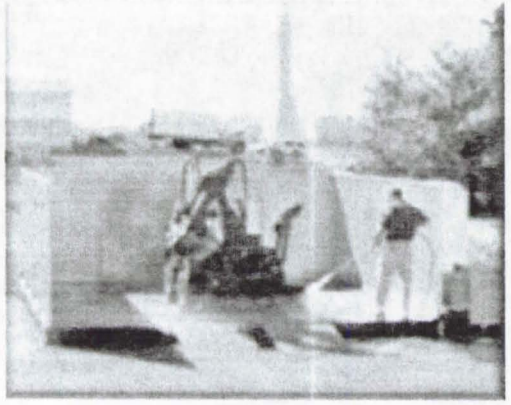
- *Directed by HQ USAF: Manage AF Corrosion Maintenance Program*
- *(AFI 21-105, Air and Space Equipment Structural Maintenance, Apr 03, in re-write*

- ***Current Projects:***
  - **Wash/Rinse Cycle Studies**
  - **C-5 Transition to PreKote**
  - **"Green" Wash Racks**
  - **Transition to Plastic Media Blasting**
  - **Annual Corrosion Surveys**

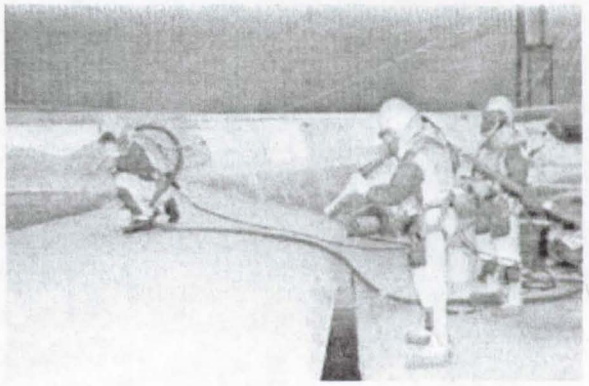
Key Players:
USAF Corrosion Prevention and Control Office

"Green" Wash racks

- Solar-powered w/ recycled & purified wash water
- De-Ionizing fliters in the waste stream
- Closed Loop water re-circulation
- 84% water conserved – 13 GPM



Transition to Plastic Media Blast



- Replaced scuff-sand & overcoat
- Reduced thickness by as much as 15 mils in places
- Faster; Lighter weight = fuel savings

Key Players:
USAF Corrosion Prevention and Control Office

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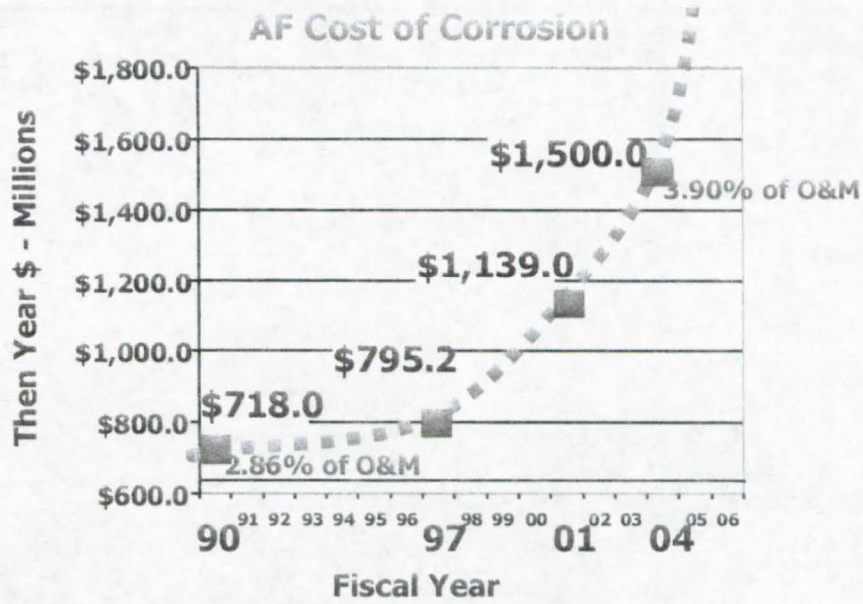
Annual Corrosion Survey

- Currently Conducting AF cost of corrosion Survey for 2009
- $83.9 Billion is spent on DoD Maintenance per year
- $23.4 Billion is spent on AF
  - $10.1 Billion on depot MX
  - $13.3 Billion on field MX



$1.5B/yr = 3.9% of O&M Budget

Aircraft Corrosion = $1.17B/yr

Key Players:
HQ USAFSPC

- **USAF Space Command has funded over $1.85M in pollution prevention projects**

- **Completed Projects 2009**
  - **AFSPC/NASA Launch Coatings Dem/Val**
  - **Pollution Prevention Opportunity Assessment for AFSPC Coatings Operations: 90th Space Wing, F.E. Warren Air Force Base**
  - **Pollution Prevention Opportunity Assessments for AFSPC Eastern Range Operations: Cape Canaveral Air Force Station & Jonathan Dickinson Missile Tracking Annex**

- **Pending Projects 2009+**
  - **ICBM Support Equipment: Transporter Erector Dem/Val**
  - **Missile Suspension System Minuteman III Weapons System Support Coatings Dem/Val**

Key Players:
HQ USAFSPC

AFSPC & NASA Launch Coatings

- Project Goals/Requirements
  - Investigate Low/No VOC non-hazardous (high temperature) alternative coating solutions for launch facilities.
  - This funding addressed field testing of alternative coating systems for AFSPC launch facilities.
  - Coating System must survive 1 launch
- Focus Areas
  - High temperature coating
  - Environmentally friendly coatings and depaint process

AFSPC & NASA Launch Coatings

TRL 8

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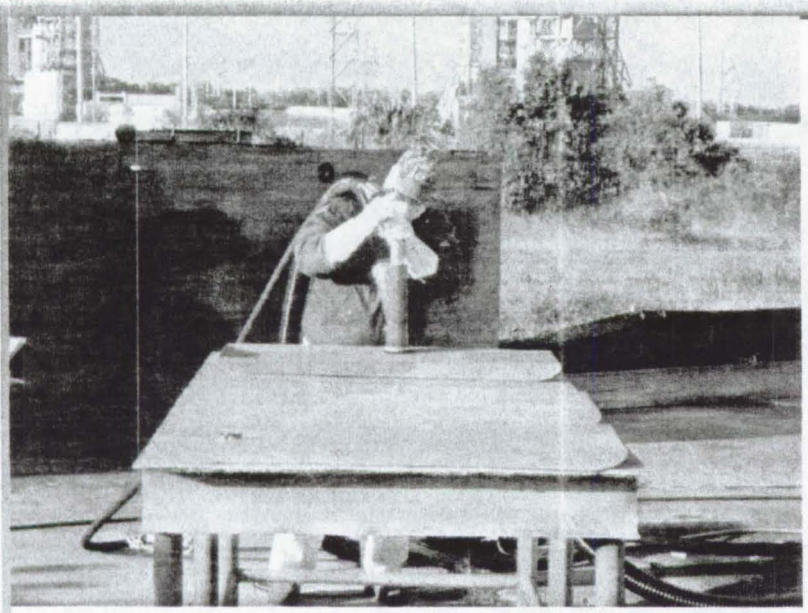
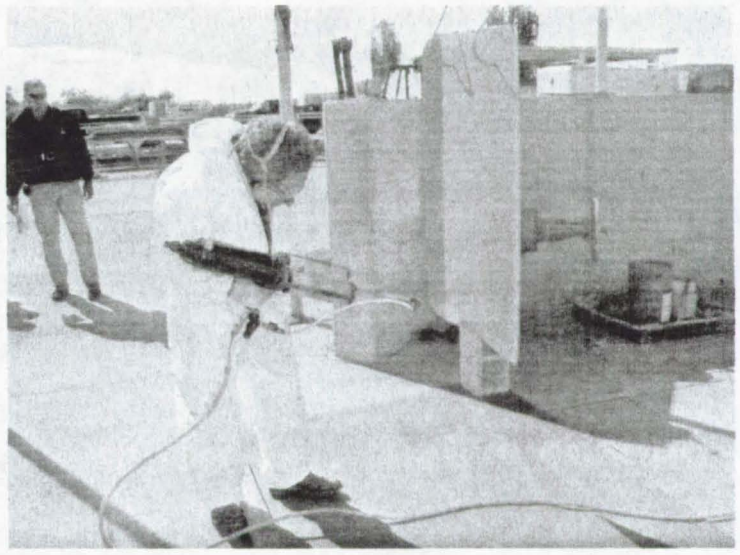
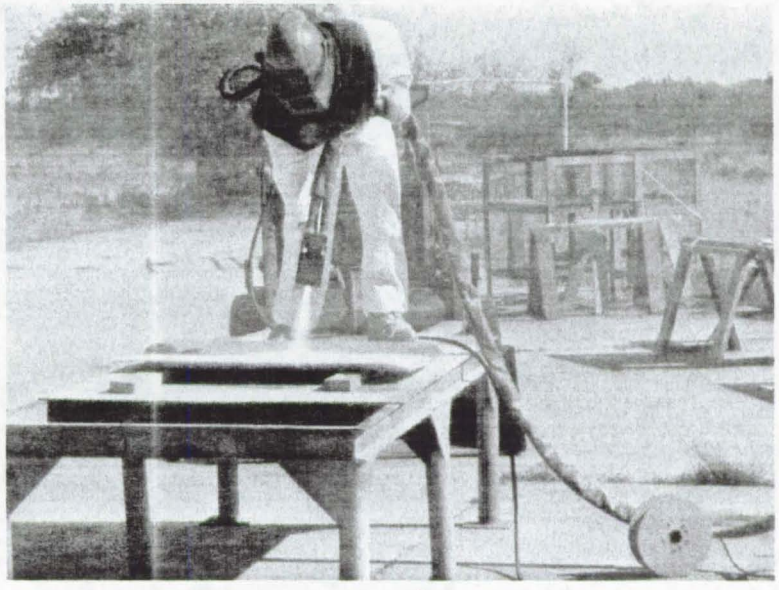


Depaint with Blast Recovery System (BRS)



GE Ablative Application



Metallization (MWAS)

AFSPC & NASA Launch Coatings

TRL 8

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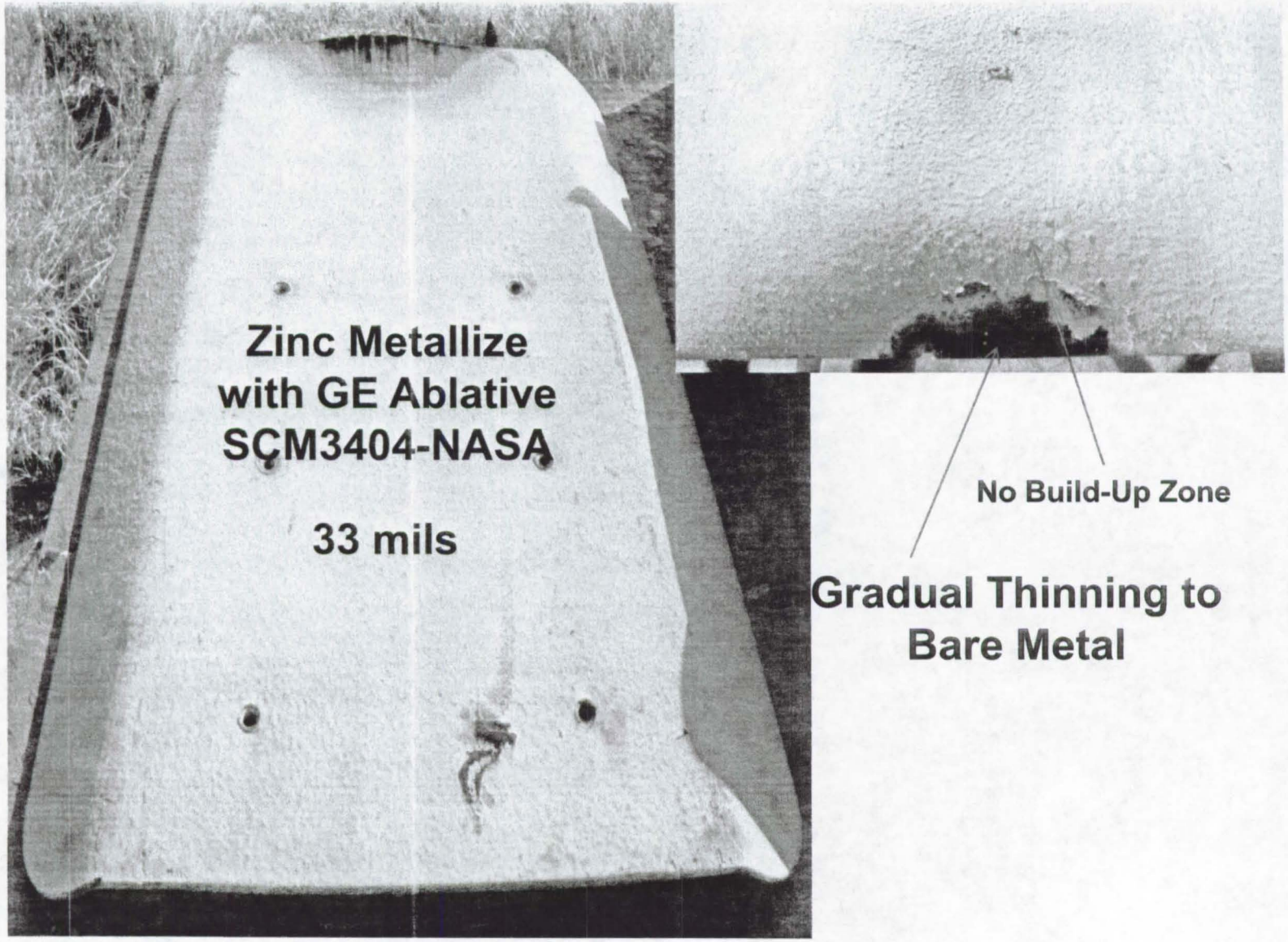

AFSPC & NASA Launch Coatings

TRL 8

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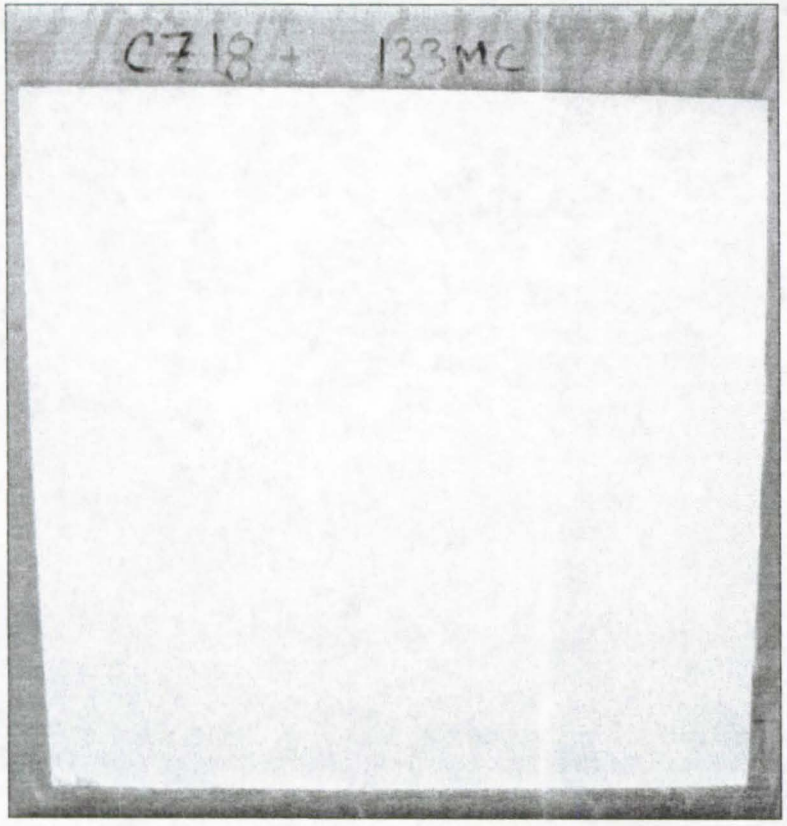
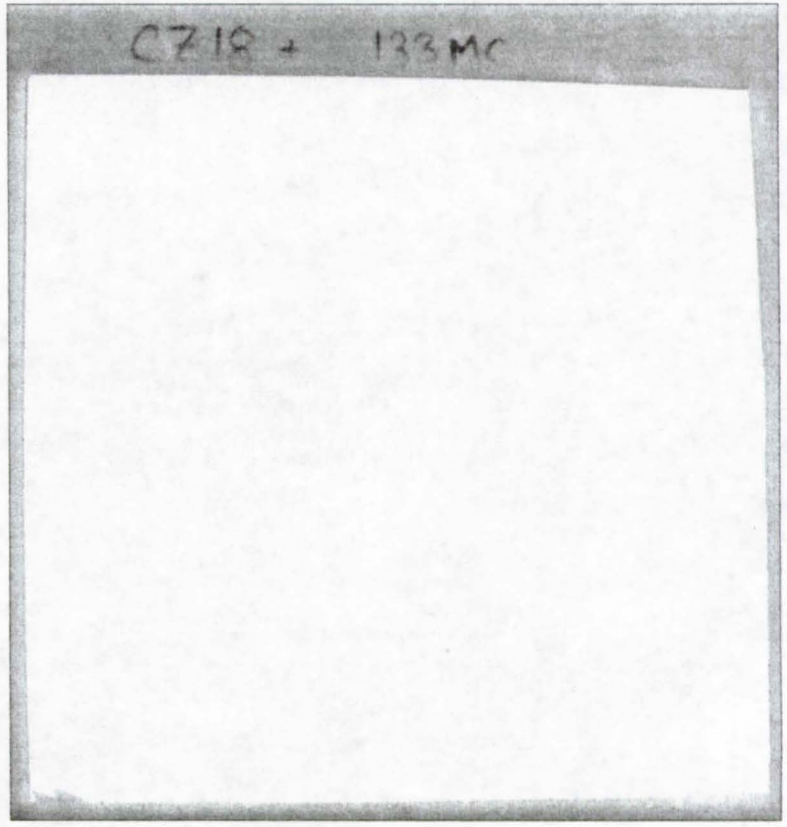


Carboline System, Completed System, Cured, Pre-Launch.



Carboline System, Post-Launch.

AFSPC & NASA Launch Coatings

TRL 8

- Agenda
- Key Players:
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- Tech Overview: Metallization
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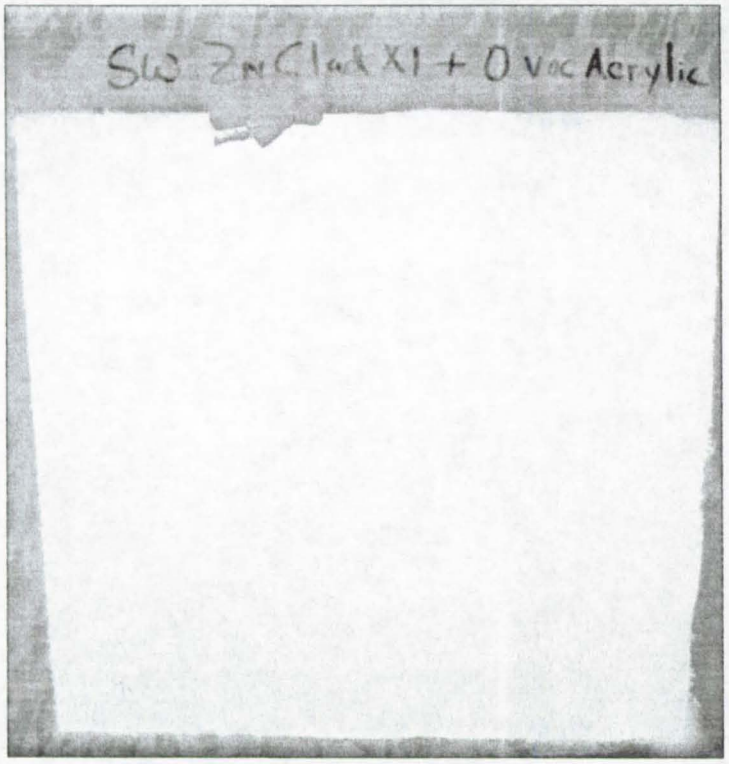

Sherwin-Williams System, Completed System, Cured, Pre-Launch.

Sherwin-Williams System, Post-Launch.

AFSPC & NASA Launch Coatings

TRL 8

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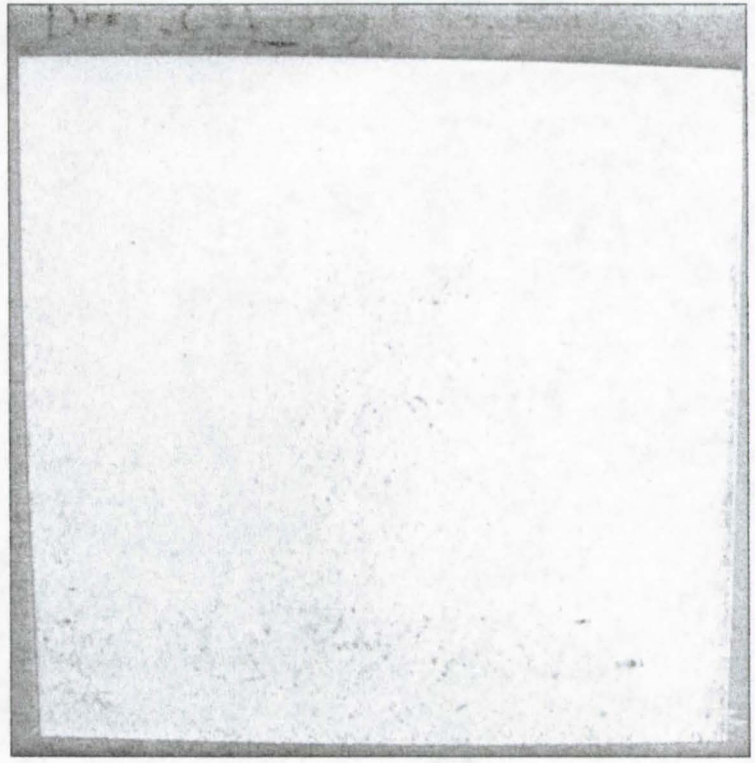
Deft System, Completed System, Cured, Pre-Launch.



Deft System, Post-Launch.

Key Players:
USAFSPC

- **Pollution Prevention Opportunity Assessments**
  - **Project Goals/Requirements**
    - **Opportunity assessment of de-painting, surface preparation, & coating application processes currently used at AFSPC range operations.**
    - **Provided data analysis and recommendations, a Cost Benefit Analysis and assessment to reduce environmental burden/risk processes and identify alternative environmentally preferable coating systems.**
    - **Analyzed existing processes, hazardous waste disposal, environmental regulations, environmental control equipment, & identify new equipment necessary to perform revised process.**
  - **Performed at Vandenberg AFB and FE Warren AFB**

Key Players:
USAFSPC

- **Efforts in Progress (FY-09, FY-10)**
  - **Support Equipment Coatings: Transporter Erector (ICBM SE) (MAFB)**
  - **Missile Suspension System (VAFB)**
  - **Launch Coatings Alternatives (VAFB)**
  - **AFSPC Eastern Range Coatings Pollution Prevention Support (PAFB)**

Key Players:
USAFSPC

Support Equipment Coatings:

Transporter Erector (ICBM SE) (MAFB)

— Project Goals/Requirements

- Continuation of Low/No VOC Corrosion-Preventive Coatings for ICBM Missile Support Equipment
- Incorporation of low-VOC coatings for AGE use
- Lower hazardous waste production and environmental impact of operations

Transporter Erector

TRL 8

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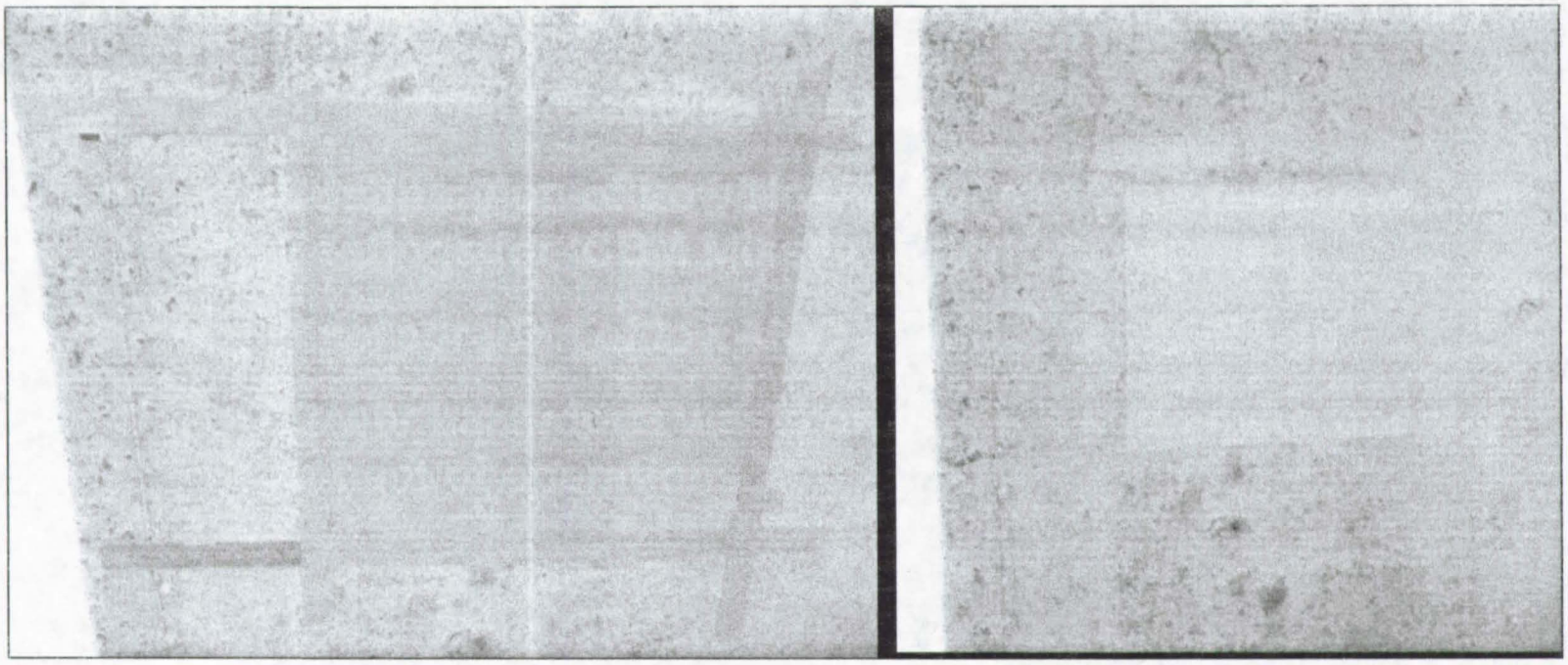

Under Container, Right Side, Scuffed Existing Polyurethane for Surface Repair Only (Not to Bare Metal) with 180-grit Sandpaper on a Random Orbital Sander, Wiped Clean with Denatured Alcohol, Coated with Deft 02-GN-084 and Deft 55-W-002.

Transporter Erector

TRL 8

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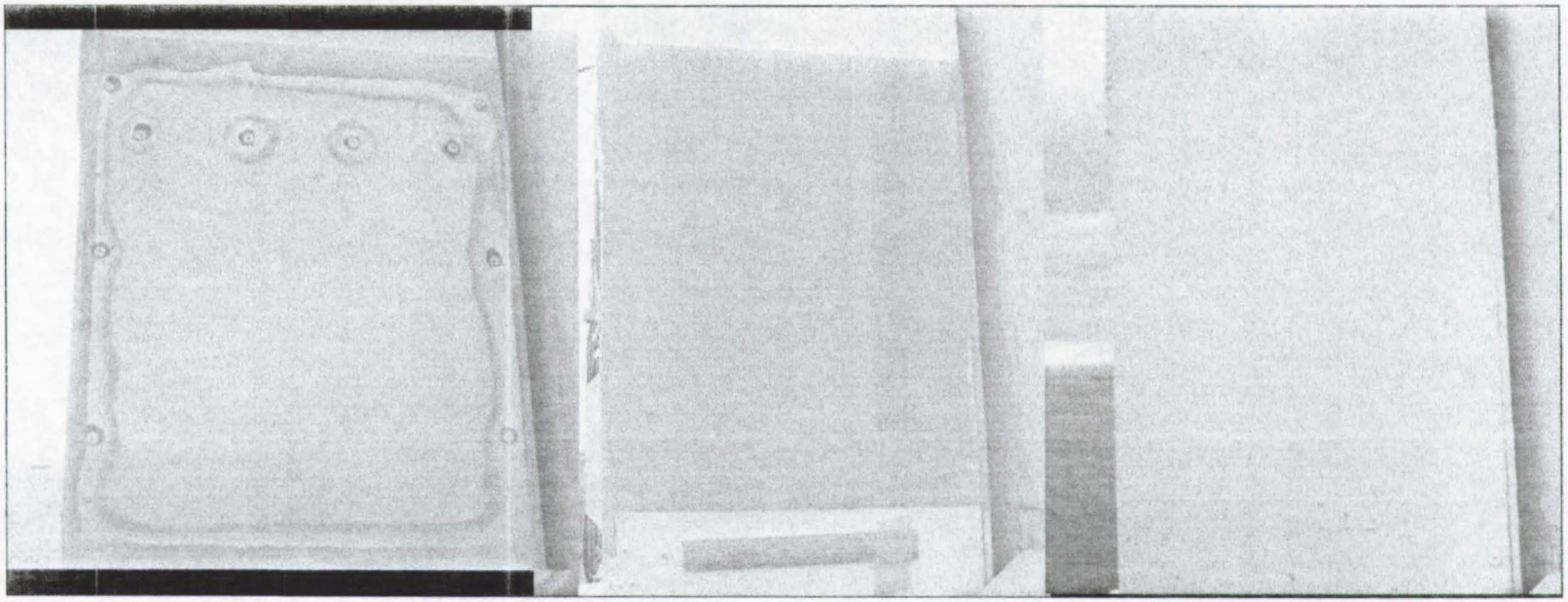
Cold Spray Technology
Metallization Project



ECS Air Inlet Box, Upper Section, Scuffed to Bare Metal (Aluminum) with 180-grit Sandpaper on a Random Orbial Sander, Washed Clean with the PreKote process, Coated with Deft 02-GN-084 Primer and and Deft 55-W-002.

Transporter Erector

TRL 8

Agenda
Key Players:

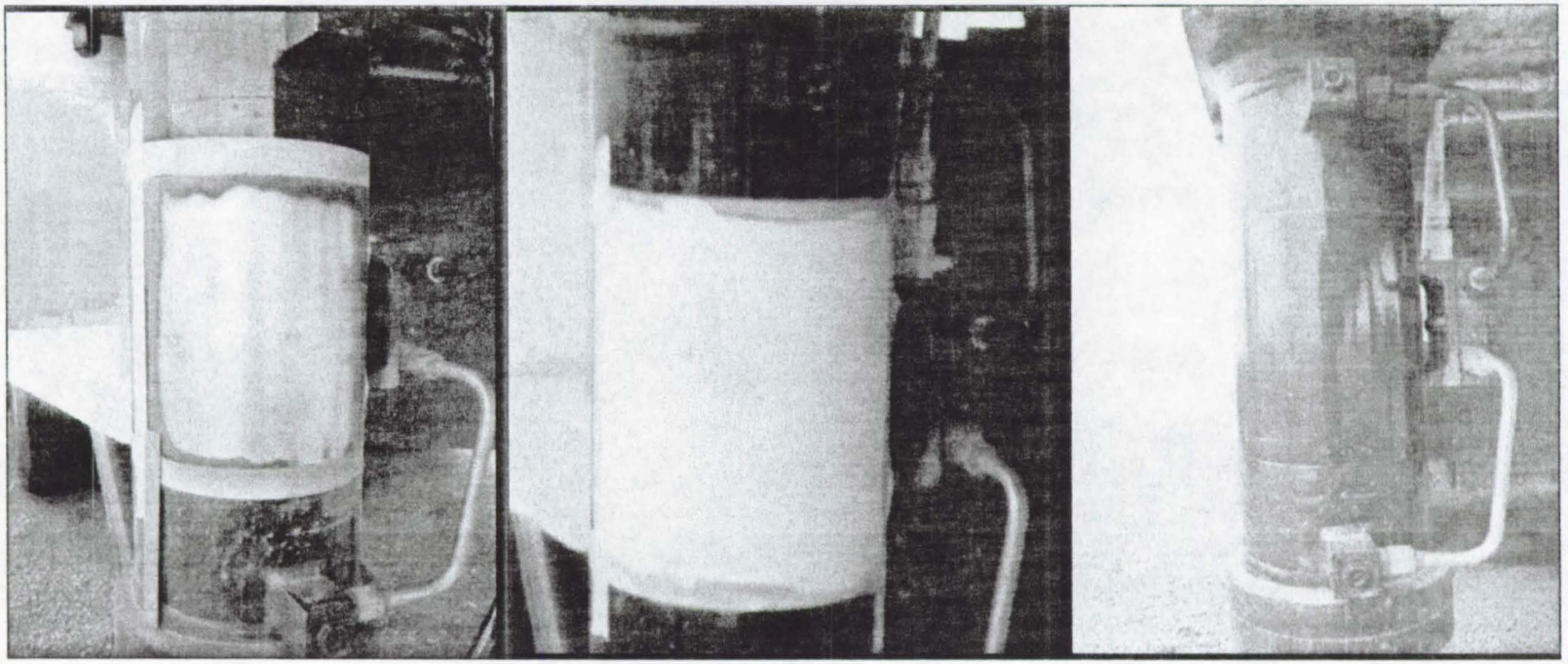
AFCTIO
AFCPCO
AFSPC
NASA

Tech Overview:
Metallization

Metal Wire Arc Spray

Cold Spray Technology

Metallization Project



Right Front Landing Gear, Scuffed to Bare Metal (Steel) with 180-grit Sandpaper on a Random Orbital Sander, Wiped Clean with Denatured Alcohol, Coated with Deft 02-W-052 and Deft 55-BL-007.

Transporter Erector

TRL 8

Agenda
Key Players:

AFCTIO
AFCPCO
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Tech Overview:
Metallization

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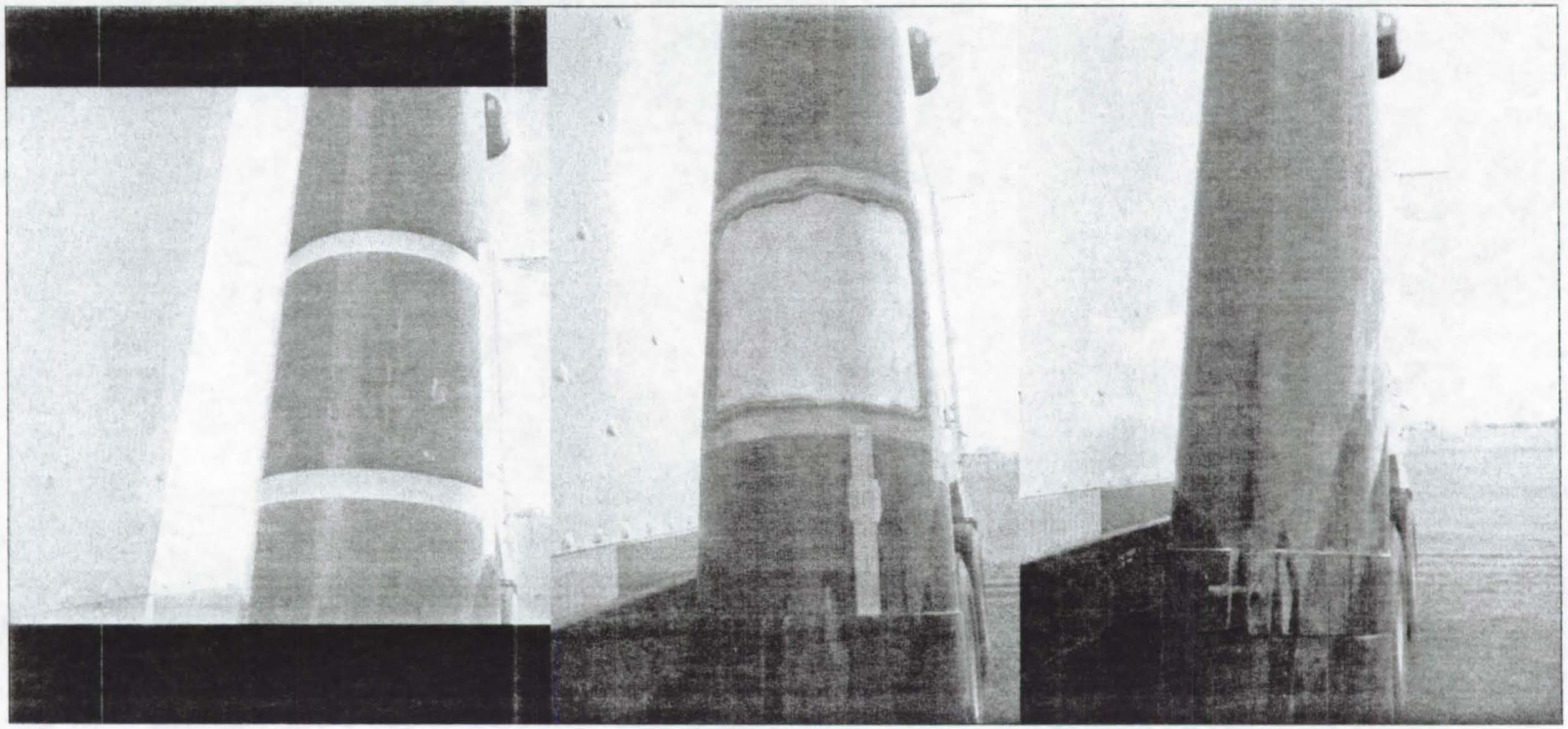
Metallization Project



Left Right Actuator, Scuffed to Bare Metal (Steel) with 180-grit Sandpaper on a Random Orbital Sander, Wiped Clean with Denatured Alcohol, Coated with Deft 02-W-052 and Deft 55-BL-007.

Key Players:
USAFSPC

Missile Suspension System

- Project Goals/Requirements
  - Demonstrate/Validate metallization for high-temperature applications
  - Platform is the Minuteman III weapons system support equipment (MSS) for the 309 MMXG depot refurbishment squadron located at Vandenberg AFB
  - Project carried forward suggestions from a P2OA for Vandenberg AFB
    - Reviewed coatings work performed by other DoD groups
      - NASA TEERM
      - AFRL/RXBT
      - AFRL/RXSSO

Missile Suspension System

TRL 8+

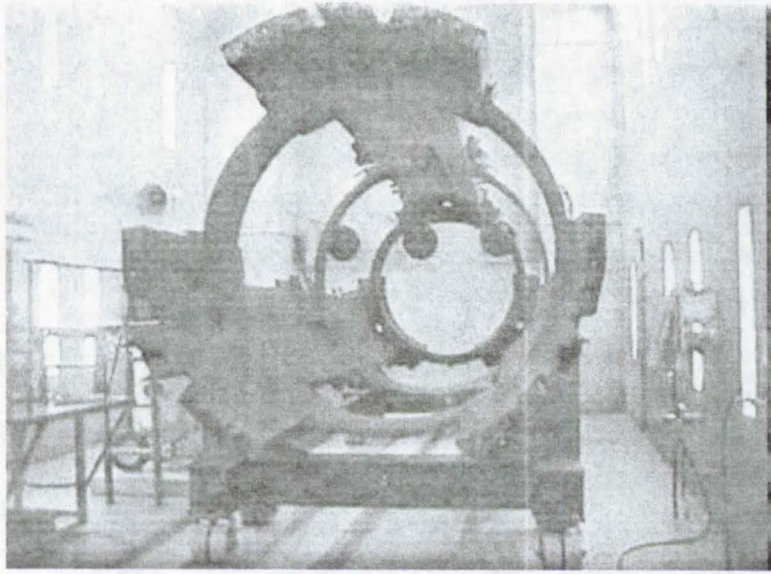
Agenda
Key Players:

AFCTIO
AFCPCO
AFSPC
NASA

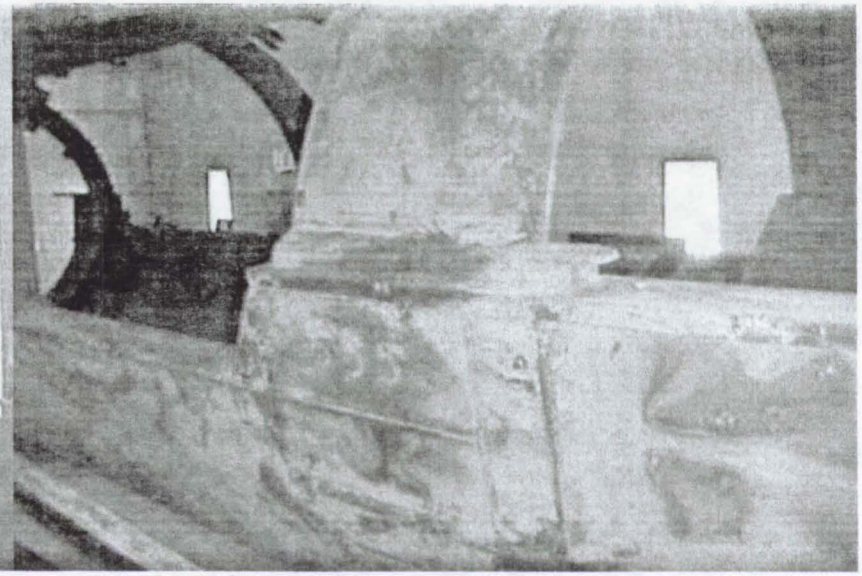
Tech Overview:
Metallization

Metal Wire Arc Spray

Cold Spray Technology Metallization Project



Missile Suspension System (MSS)



Red-Oxide Primer with Latex Topcoat-Post Launch

Key Players:
USAFSPC

- **Launch Coatings Alternatives**
  - **Project Goals/Requirements**
    - **This program builds upon the technology demonstrations performed in collaboration between NASA and AFSPC at Cape Canaveral Air Force Station (CCAFS). Previous programs by NASA, AFSPC, and AFRL to investigate Low/No VOC non-hazardous alternative coating solutions have identified alternate coating systems for launch facilities.**
    - **Investigate Low/No VOC non-hazardous (high temperature) alternative coating solutions for launch facilities.**
    - **This funding will address field testing of alternative coating systems for AFSPC launch facilities in the applicable installation and/or range locations.**
- **Focus Areas**
  - **Ceramic coatings**
  - **Environmentally friendly liquid coatings**
  - **Metallization**
  - **Cold spray**
  - **Depaint process/improvements**

Key Players
NASA

Low Emission Depaint Operations on steel

Goal was to validate alternative low emission surface preparation/ depainting technologies for structural steel.

- Sponge Media, Hard Abrasive Media, and Plastic Blast Media technologies performed best for large areas.
  - Reduced particulate emissions.
  - Recyclable media results in less waste; Two technologies (Hard Abrasive and Plastic Blast Medias) result in zero waste.
- Mechanical Removal with Vacuum Attachments performed well for small areas.
  - Practically zero emissions.
  - No secondary waste.

Key Players
NASA

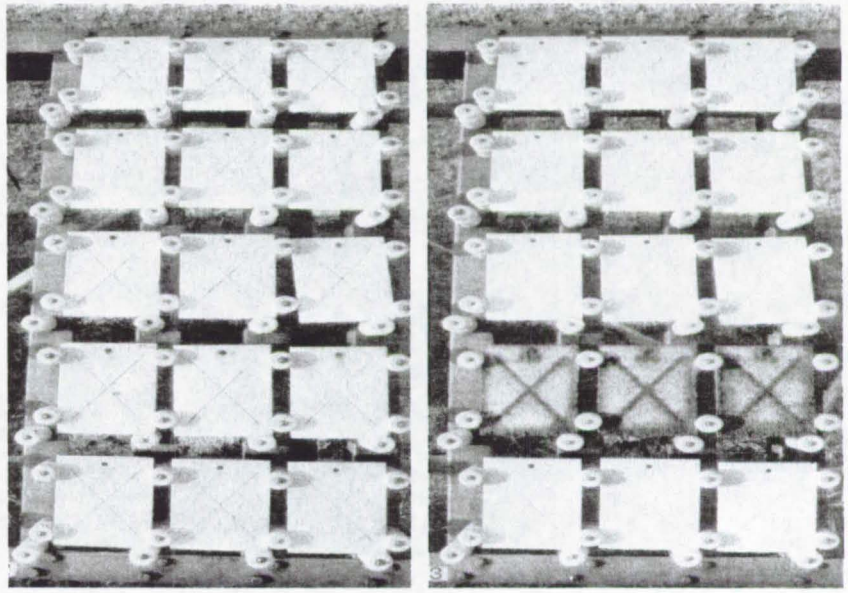
Alternatives to Isocyanate Urethanes

Goal is to validate environmentally preferable alternatives to isocyanate urethane coatings currently used across NASA and AFSPC on structural and non-structural elements.

- **Benefits**
  - **Reduced risk associated with environmental, safety, and health concerns that come with the use of isocyanates, VOCs, and HAPs.**
  - **Reduced material obsolescence risk due to environmental and safety regulations.**

Results:

Five coatings systems were approved for the QPL for NASA std 5008A



AFRL

THE AIR FORCE RESEARCH LABORATORY

LEAD | DISCOVER | DEVELOP | DELIVER

Technical Overview: Metallization

Tech Overview:
Metallization

- **Metallization is a process used to deposit a thin layer of metal over a surface.**
  - **Currently 2 types of Metallization are being developed for use in USAF/Space applications**
    - **Metal wire arc spray**
      - **This method uses two separate charged wires, these wires are fed through the apparatus and struck by an electrical arc. When acted apon by the arc, they are both transformed into a molten state. This molten metal is then atomized and sprayed onto the substrate.**
    - **Cold-Spray**
      - **This method uses energy stored in high pressure compressed gas to propel fine powder particles at speeds up to 1500m/s. Bonding relies on sufficient energy to cause significant plastic deformation.**

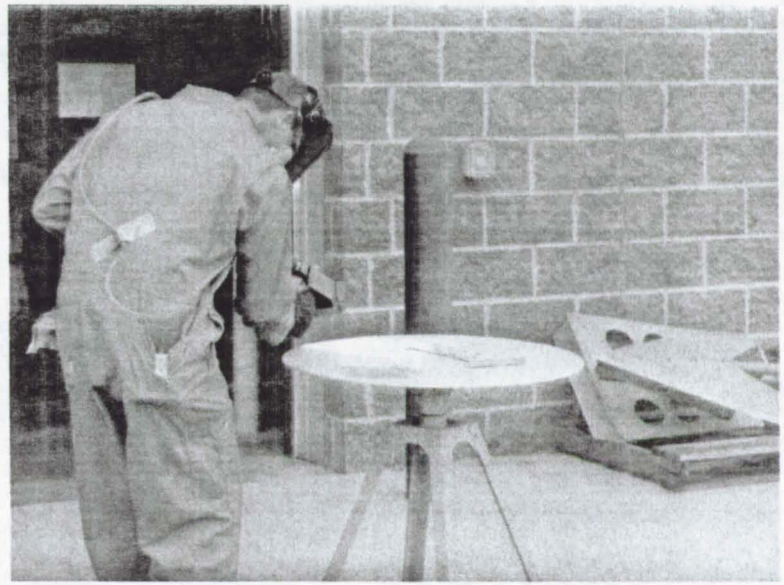
Tech Overview Metallization

A Closer look at metal wire arc spray (MWAS).

- **MWAS is a versatile, affordable solution for coating repair**

- **A wide range of Metals can be sprayed with this method, including but not limited to Al, Ag, Au, Mg, ZN**

- **The USAF has approved a 85% Zn 15% Al mixture for use in the field.**



Tech Overview
Metal Wire Arc Spray

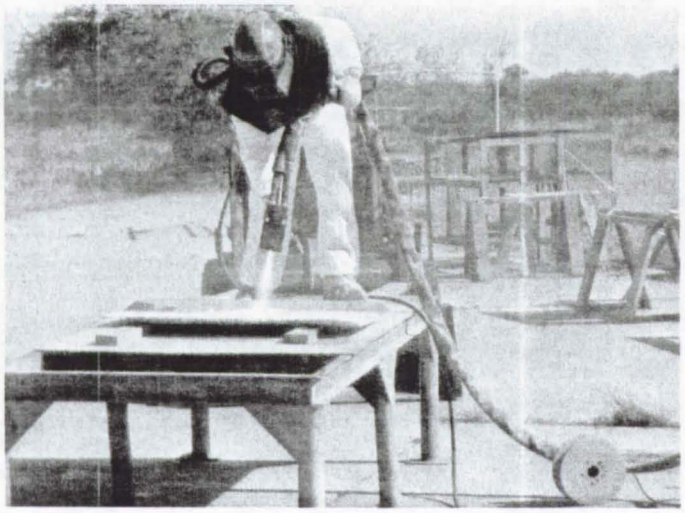
Agenda
Key Players:

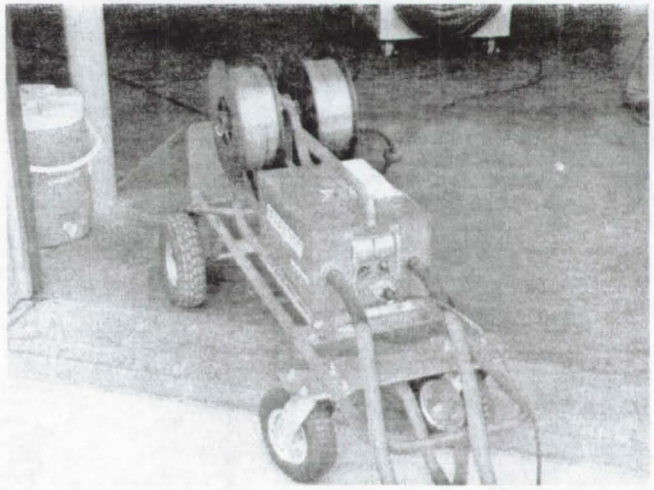
AFCTIO
AFCPCO
AFSPC
NASA

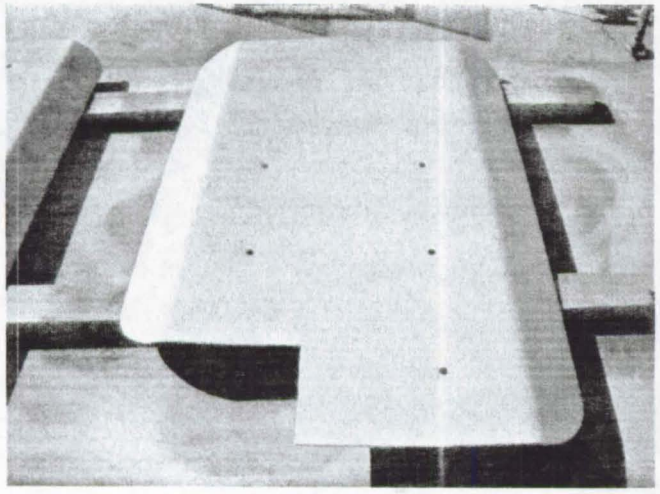
Tech Overview:
Metallization

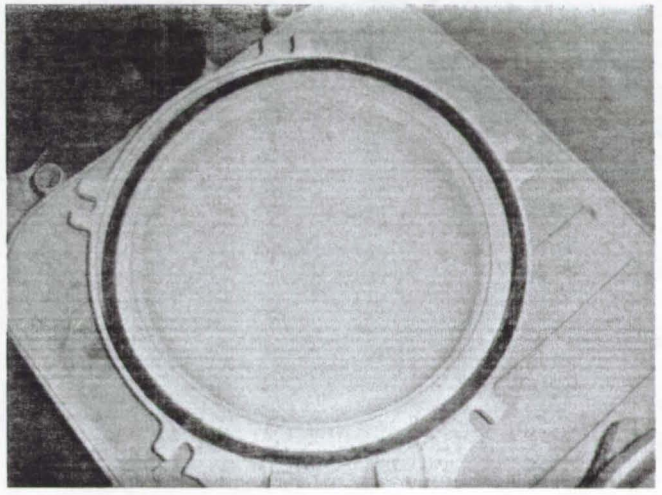
Metal Wire Arc Spray

Cold Spray Technology Metallization Project



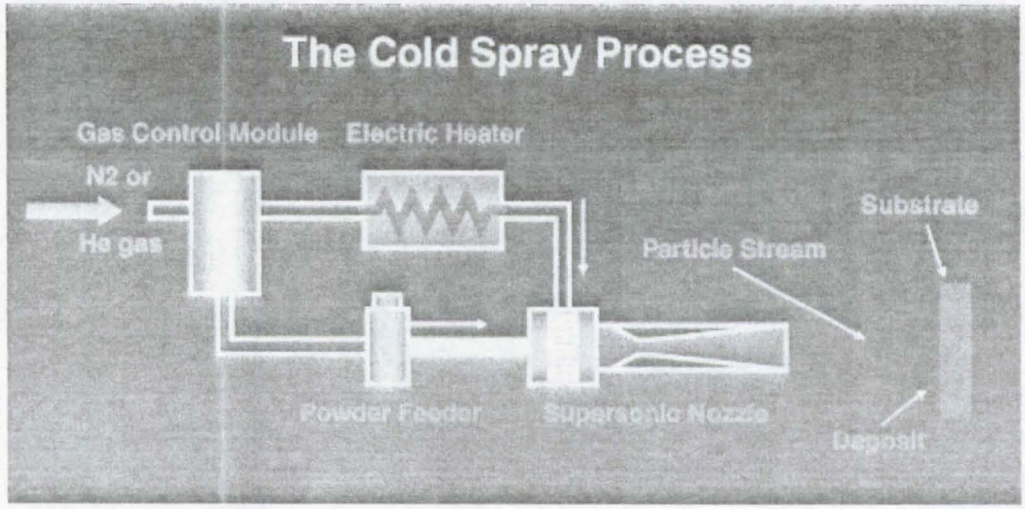






Tech Overview
Metallization

- **Advantages**
  - Low temperature
  - Retains composition of particles
  - Eliminates solidification stress, can produce thicker coatings
  - Very little oxidation



- **Disadvantages**
  - High gas consumption, mainly He
  - More expensive than MWAS

Cold Spray Field Eval

Agenda
Key Players:

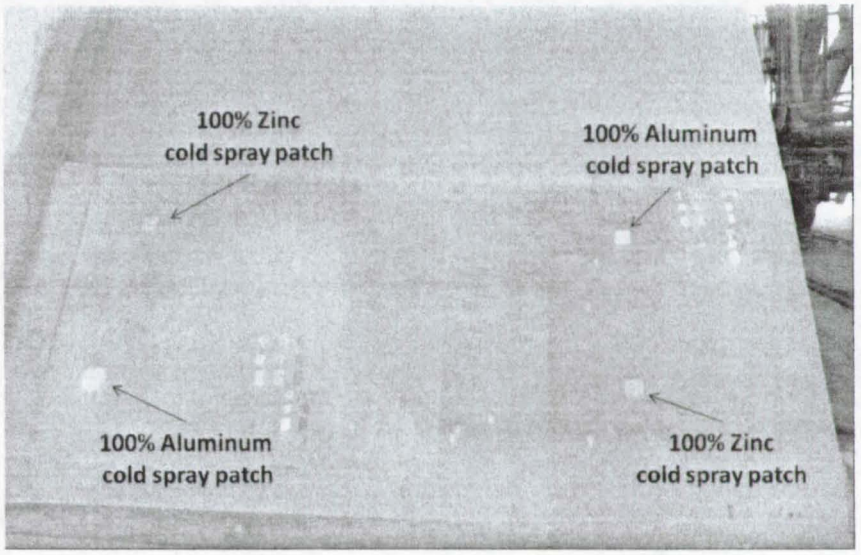
AFCTIO
AFCPCO
AFSPC
NASA

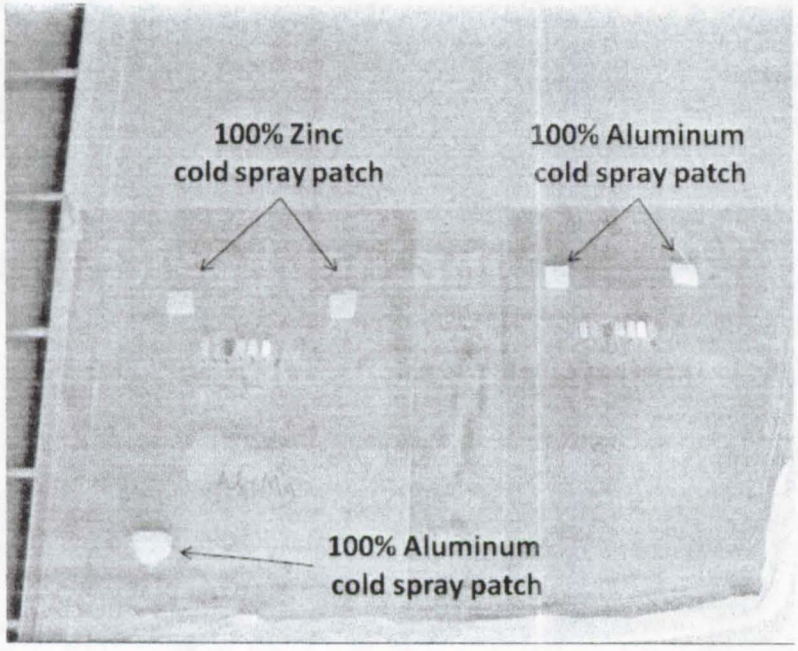
Tech Overview:
Metallization

Metal Wire Arc Spray

Cold Spray Technology Metallization Project

Left Flame Deflector Plate, Cold Spray Patch Applications to Metallize in Deluge Pit, SLC-17A.

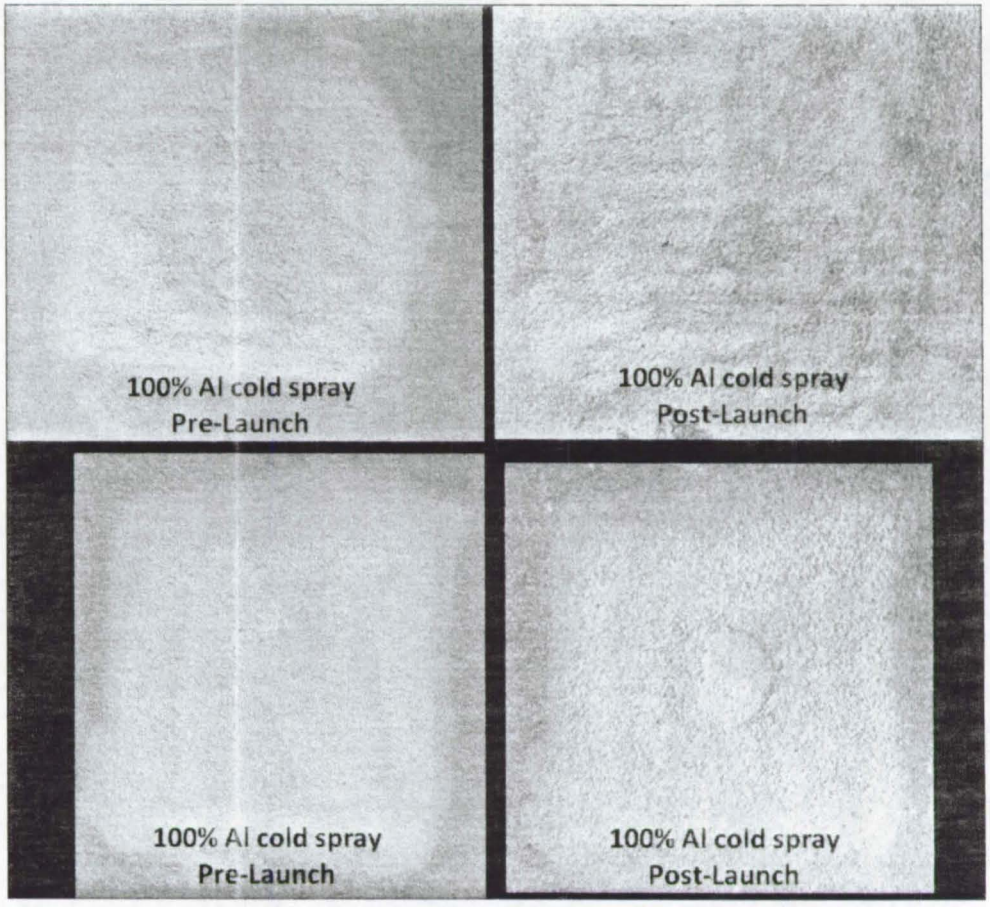




Right Flame Deflector Plate, Cold Spray Patch Applications to Metallize in Deluge Pit, SLC-17A.

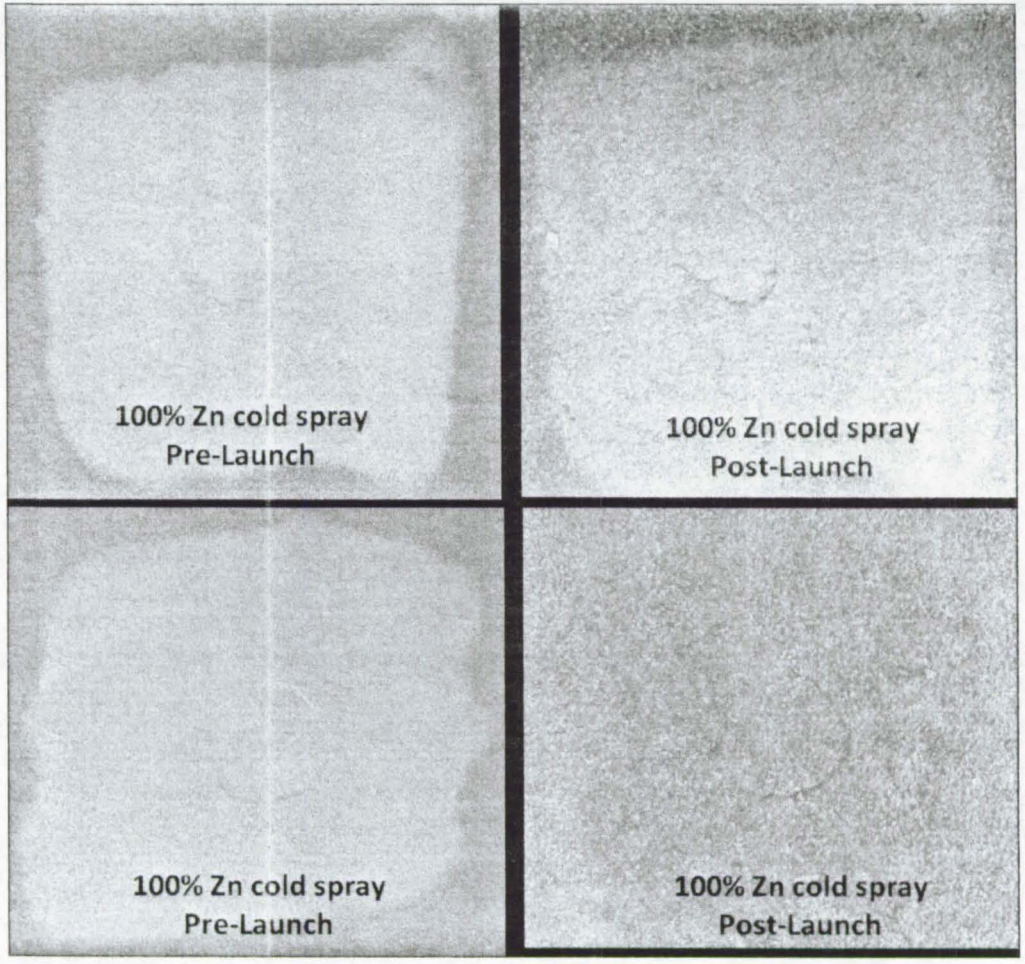
Cold Spray Field Eval

- **A near 100% aluminum powder was utilized as the repair material for the aluminum/magnesium metallize in the deluge pit area, instead of the nickel blends. The nickel blends had issues with moisture and resulted in poor application.**



Cold Spray Field Eval

- **There were no noticeable issues during the application of the zinc powder.**



Joint AFSPC/NASA Launch Coatings

Test and qualify low-VOC, non-hazardous materials and processes for large-area painting and depainting maintenance operations of structures across NASA and AFSPC.

- **Benefits**
  - Eliminates risk associated with environmental, safety, and health concerns with use of paints and coatings of high VOC content and particulate emissions from depainting operations.
  - Project is a continuation of previous studies conducted by NASA TEERM and AFSPC (AIU Coatings, Low Emission Depainting, Vandenberg demos) thus reducing duplication of effort and costs
- **Achievements**
  - Fixed Umbilical Tower Coatings:
    - Applied to areas that are subjected to extreme heat and exhaust gases during a launch.
    - Two thermal spray coatings (Zn and Al-Mg).
    - Ablative coating (currently used on Pads 39 A & B).
  - Mobile Support Tower Coatings:
    - To be evaluated at 6, 12, and 18 months.
    - The two thermal spray coatings were applied and topcoated with a low VOC waterborne coating.
    - Three liquid coating systems that are low VOC were applied

AFSPC & NASA Launch Coatings

Agenda
Key Players:

AFCTIO
AFCPCO
AFSPC
NASA

Tech Overview:
Metallization

Metal Wire Arc Spray

Cold Spray Technology

Metallization Project

System	Components	Pot life at 75°F	DFT, mils
1	Interzinc 22HS (primer)	4 hours	4 - 6, primer
	Interseal 670HS (intermediate)	8 hours	8 – 10, intermediate
	Interfine 979 (topcoat)	2 hours	20 - 22, full
2	53/56 aluminum/magnesium wire		15 - 16, primer
	No intermediate		
	Kimetsan AquaSurTech (AST)	6 hours	16 - 17, full
3	100 % zinc wire		15 - 16, primer
	No intermediate		
	Kimetsan AquaSurTech (AST)	6 hours	16 -17, full
4	Carbozinc 11 WB (primer)	8 hours	5 - 7, primer
	Carboguard 893 (intermediate)	4 hours	9 - 13
	Carboacrylic 3359 DTM (topcoat)	24 hours	16 - 18, full
5	Carbozinc 11 WB (primer)	8 hours	5 - 7 , primer
	No intermediate		
	Carboxane 2000 (topcoat)	8 hours	13 - 14, full

AFSPC & NASA Launch Coatings

Agenda
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AFCTIO
AFCPCO
AFSPC
NASA

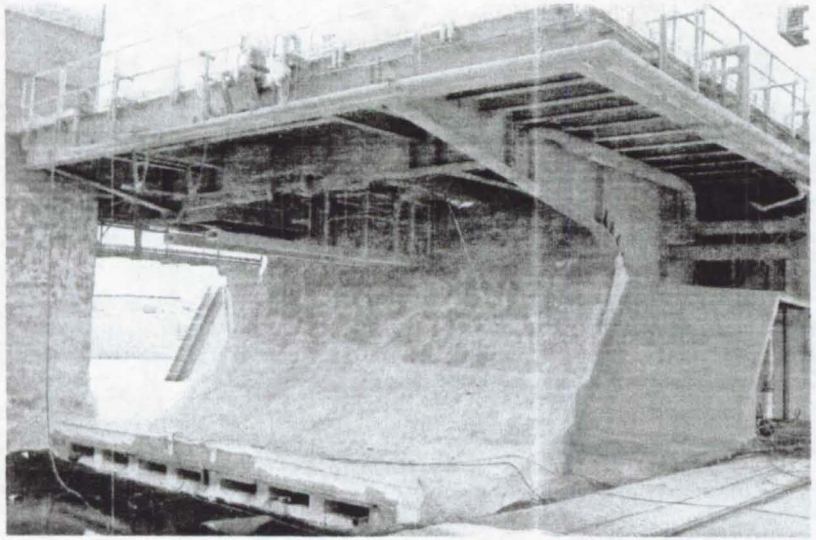
Tech Overview:
Metallization

Metal Wire Arc Spray

Cold Spray Technology

Metallization Project

Conducted evaluation of TSC and Ablative Alternatives placed on the Space Launch Complex 17, Pad A, Fixed Umbilical Tower after each of four successive launches:



CCAFS SLC 17 Fixed Umbilical Tower

Application of Thermal Spray Coating

AFSPC & NASA Launch Coatings

Agenda
Key Players:

AFCTIO
AFCPCO
AFSPC
NASA

Tech Overview:
Metallization

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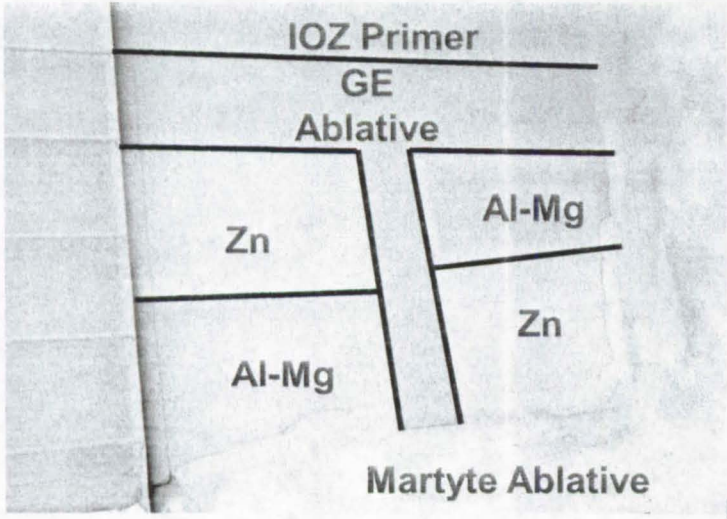
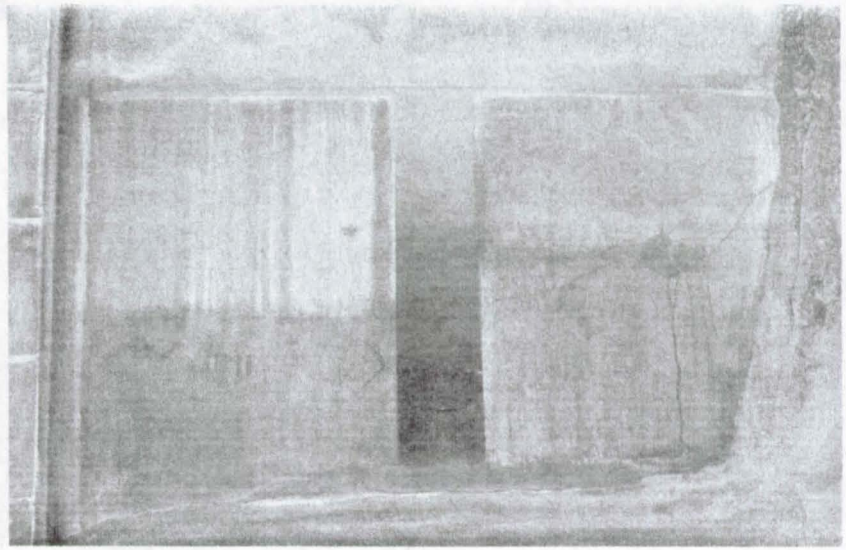
Cold Spray Technology

Metallization Project

Coatings before launch



Coatings after four launches



AFSPC & NASA Launch Coatings

- **Observations to date:**
  - **Thermal spray coatings:**
    - **Excellent heal and chemical resistance**
    - **Little coating thickness loss.**
    - **Acceptable adhesion performance**
    - **Remain on the site for a 5th launch!**
  - **Ablative coatings performed as expected, but it was determined that a thicker layer than applied during this demonstration is required.**

Materials Management and Substitution

Questions?